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1×10^{16} cm^{-3}, no substantial change occurs in the band profile. The above-described configuration is provided on the GaAs substrate **61** with a well-known semiconductor-process technology such as providing semiconductor layers **612**, **603**, and **602** in sequence through crystal-growth by using the molecular beam epitaxy (MBE) method or the metal-organic vapor phase epitaxy (MOVPE) method, etching the semiconductors **612**, **603**, and **602** so that the semiconductors are processed into a mesa, performing passivation by using an SiO$_2$ layer **605**, etc. The mesa should have a small area to minimize the RC time constant, and the small area should be a little larger than a projected area obtained by the light irradiation. In the present embodiment, the value of the small area is determined to be 10 μm×10 μm.

[0061] For performing operations of the present embodiment, a voltage is applied from a voltage source **620** between the electrodes **601** and **611** so that the electric field intensity of the travel section **603** is adjusted to about 50 V/cm. In the present embodiment, a 1.5 μm-band fiber laser device configured to oscillate short-pulse light having a width of a few tens of femtoseconds is used. The Ti/Pt/Au electrode **611** provided directly above the AlGaAs-potential barrier **602** is irradiated with Femtosecond-pulse light **631**. Since a wavelength of 1.5 μm corresponds to the photon energy 0.8 eV, an electron can be photoexcited so that the electron can go beyond the AlGaAs-potential barrier **602** having a height of about 0.7 eV. Further, the sub-collector **612** is designed to have a band gap of about 1.4 eV so that the electrical conductivity of the sub-collector **612** is not significantly changed due to the irradiation of the Femtosecond-pulse light **631**, that is, the excitation light **631**.

[0062] In FIG. 6C, the first electrode **601** includes an interdigital-shaped part illustrated with reference numeral **606**. Since the first electrode **601** includes the interdigital-electrode part **606** so as not to interfere with the transmission of the light **631**, the light efficiency of the present embodiment is increased to a certain degree. The time period τ during which an emitted current flows depends on the material of the GaAs-travel section **603**. When an electric field of 20 to 200 kV/cm is applied to GaAs at ambient temperatures, the value of electron-travel speed v$_d$ is about 0.8×10^7 cm/sec, which is found on referring to "J. S. Blakemore, Jour. Appl. Phys. Vol. 53, 8123 (1982)" describing an investigation of the material characteristics of GaAs. Accordingly, it can be estimated that the equation τ=0.38 psec holds based on the equation τ=d/Vd. Since a radiation pattern is radiated toward the GaAs substrate **61** having high permittivity, a semi-insulating substrate **61** decreasing the loss of the THz wave may be used.

Seventh Embodiment

[0063] An electromagnetic-wave generation device according to a seventh embodiment will be described with reference to FIGS. 7A, 7B, and 7C. FIG. 7A is a sectional view of the electromagnetic-wave generation device of the present embodiment. FIG. 7B illustrates the band profile of a semiconductor part, which is obtained along a section of the electromagnetic-wave generation device of the present embodiment. FIG. 7C is a top view of the electromagnetic-wave generation device of the present embodiment. The present embodiment includes a combination of the second and third embodiments.

[0064] FIG. 7A illustrates an InP substrate **71** on which the present embodiment is provided, a Ti/Pd/Au electrode (first electrode) **701** provided on a passivation layer **705**, and a

potential barrier **702** including an 8-nanometer-thick InAlAs layer achieving a tunneling probability of 0.1% near the Fermi energy. FIG. 7A further illustrates a 100-nanometer-thick n-InGaAs layer **704** having an electron density of 1×10^{19} cm^{-3}, and the Fermi energy of the n-InGaAs layer **704** lies near the bottom of the conduction band.

[0065] In this embodiment, the electrode **701**, the n-InGaAs layer **704**, and the InAlAs-potential barrier **702** constitute an emitter section. Therefore, the height of the InAlAs-potential barrier **702** matches up with the band offset between InGaAs and InAlAs, and the height value becomes of about 0.5 eV. A travel section **703** includes a 60-namometer-thick i-InGaAs layer, and a 100-nanometer-thick n-InP layer **712** has an electron density of 2×10^{19} cm^{-3} and a band gap of about 1.3 eV. Further, a Ti/Pd/Au electrode (a second electrode) **711** is provided.

[0066] In the present embodiment, the Ti/Pd/Au electrode **711** and the n-InP layer functioning as a sub-collector constitute a collector section. Each of the semiconductor layers includes a composition lattice-matched to the InP substrate **71**. FIG. 7B illustrates the band profile of a semiconductor part of the present embodiment, which is calculated with the Poisson solver. The height of the InAlAs-potential barrier **702** can be increased by distorting the Al-composition-increasing side thereof so long as the height is not more than the critical film thickness. Otherwise, the height of the InAlAs-potential barrier **702** can be decreased by distorting the Al-composition-decreasing side thereof.

[0067] For performing operations of the present embodiment, a voltage of 1 V is applied from a voltage source **720** between the electrodes **701** and **711**. Other specifics of the present embodiment are the same as those of the sixth embodiment. A laser device **730** is the same as that of the sixth embodiment. The n-InGaAs layer **704** provided directly above the InAlAs-potential barrier **702** is irradiated with femtosecond-pulse light **731**. FIG. 7C illustrates a ring-shaped part of the first electrode **701**. Since the electrode **701** includes a ring-shaped electrode part **706** so as not to interfere with the transmission of the femtosecond-pulse light **731**, and part of the n-InGaAs layer **704** is exposed, the light efficiency of the present embodiment is increased. The time period τ during which an emitted current flows depends on the material of the InGaAs-travel section **703**. The value of the electron-travel speed v$_d$ of InGaAs is about 9×10^7 cm/sec (see "K. Furuya et al, J. Phys.: Conf. Ser. Vol. 38, 208 (2006)" proposing a VFET configuration achieved based on the ballistic flight of an electron). Accordingly, it can be estimated that the equation τ=67 fsec holds based on the equation τ=d/Vd. Since a radiation pattern is radiated toward the InP substrate **71**-side having high permittivity, a semi-insulating substrate **71** decreasing the loss of the THz wave may be used.

Eighth Embodiment

[0068] An electromagnetic-wave generation device according to an eighth embodiment of the present invention will be described with reference to FIGS. 8A and 8B. FIG. 8A is a sectional view of the electromagnetic-wave generation device of the present embodiment. FIG. 8B illustrates the band profile of a semiconductor part, which is obtained along a section of the electromagnetic-wave generation device of the present embodiment. FIG. 8A illustrates an InP substrate **81**. The present embodiment is an exemplary modification of the seventh embodiment. That is, the n-InP layer **712** functioning as the sub-collector is eliminated and the position of